State of Louisiana
Department of Natural Resources
Coastal Restoration Division and
Coastal Engineering Division

2004 Operations, Maintenance, and Monitoring Report

for

WHISKEY ISLAND RESTORATION

State Project Number TE-27
Priority Project List 3

May 2004
Terrebonne Parish

Prepared by:

Jonathan L. West, Biological Monitoring Section (CRD)
&
Daniel Dearmond, Field Engineering Section (CED)

LDNR/Office of Coastal Restoration and Management
Thibodaux Field Office
1440 Tiger Drive, Suite B
Thibodaux, LA 70301

Suggested Citation:

West, J.L. and D. Dearmond. 2004. 2004 Operations, Maintenance, and Monitoring Report for Whiskey Island Restoration (TE-27), Louisiana Department of Natural Resources, Coastal Restoration Division, Thibodaux, Louisiana. 23pp.

2004 Operations, Maintenance, and Monitoring Report
For
Whiskey Island Restoration (TE-27)

Table of Contents

I. Introduction

Whiskey Island is part of the Isles Dernieres barrier island chain and is located along the southern Louisiana coast in Terrebonne Parish at 29^{o} 03' 00" N and 91^{o} 48' 00" W (figure 1). The Isle Dernieres, which separate Terrebonne Bay, Lake Pelto, and Caillou Bay from the Gulf of Mexico, is a 20 mile (32 km) long island arc segmented into four islands: Raccoon Island, Whiskey Island, Trinity Island, and East Island (McBride et al. 1989). Like all of Louisiana's barrier islands, Whiskey Island is experiencing island narrowing and land loss as a consequence of a complex interaction among global sea level rise, compactual subsidence, wave and storm processes, inadequate sediment supply, and significant anthropogenic disturbances (Penland et al. 1988, McBride et al. 1989, Penland and Ramsey 1990, List et al. 1997).

The Louisiana deltaic plain is fronted by a series of headlands and barrier islands that were formed as a result of the Mississippi River deltaic cycle. The Isles Dernieres is a barrier island arc transformed from the abandonment of the Caillou headland (part of the Lafourche delta complex), which occurred approximately 500 years B.P. (Frazier 1967, Penland and Boyd 1985). Barrier islands formed after delta lobe abandonment and marine processes reworked delta sands into barrier beaches. Submergence of the abandoned delta separated the headland from the shoreline forming a barrier island arc. The transgressive island arc cannot keep pace with the high rate of relative sea level rise and will eventually become an inner-shelf shoal (Penland et al. 1988).

Currently, the Isles Dernieres arc is exhibiting some of the highest rates of erosion of any coastal region in the world (Khalil and Lee *in press*). Erosional models have estimated that the Isles Dernieres would gradually narrow, fragment, and transgress through time eventually becoming subaqueous sand shoals between 2007 (McBride et al. 1991) and 2019 (Penland et al. 1988) unless restoration efforts are made. Shoreline erosion along the Gulf side of the islands averages 53.5 ft/yr (16.3 m/yr), with some episodes of erosion causing a loss of as much as 98.8 ft/yr (30.1 m/yr). Bayside erosion is reduced, averaging 5.6 ft/yr (1.7 m/yr) with a maximum of 10.8 ft/yr (3.3 m/yr). Land loss resulted when repeated storm impacts depleted the limited barrier sand reservoir and washed sands into tidal inlet and inner-shelf sinks. These conditions have led to the rapid landward migration (barrier island rollover) and disintegration of the Isle Dernieres as well as a decrease in the ability of the island chain to protect the adjacent mainland marshes and wetlands from the effects of storm surge, saltwater intrusion, an increased tidal prism, and energetic storm waves (McBride and Byrnes 1997).

The inter-tidal zone on Whiskey Island's Gulf of Mexico side consists of a marsh peat platform that has been exposed by shoreline erosion. Above high tide level there is a mixture of sand and broken shells. With the exception of isolated, ring-shaped dunes (normally 2.3 ft [70 cm] high and 22.97 ft [7 m] in diameter), the surface consists of a bare washover flat with notable salt incrustation on the north side. The eroding central part of this island consists of a layer of bare sand and shell on the marsh peat platform (Ritchie et al. 1989). Soil types in the

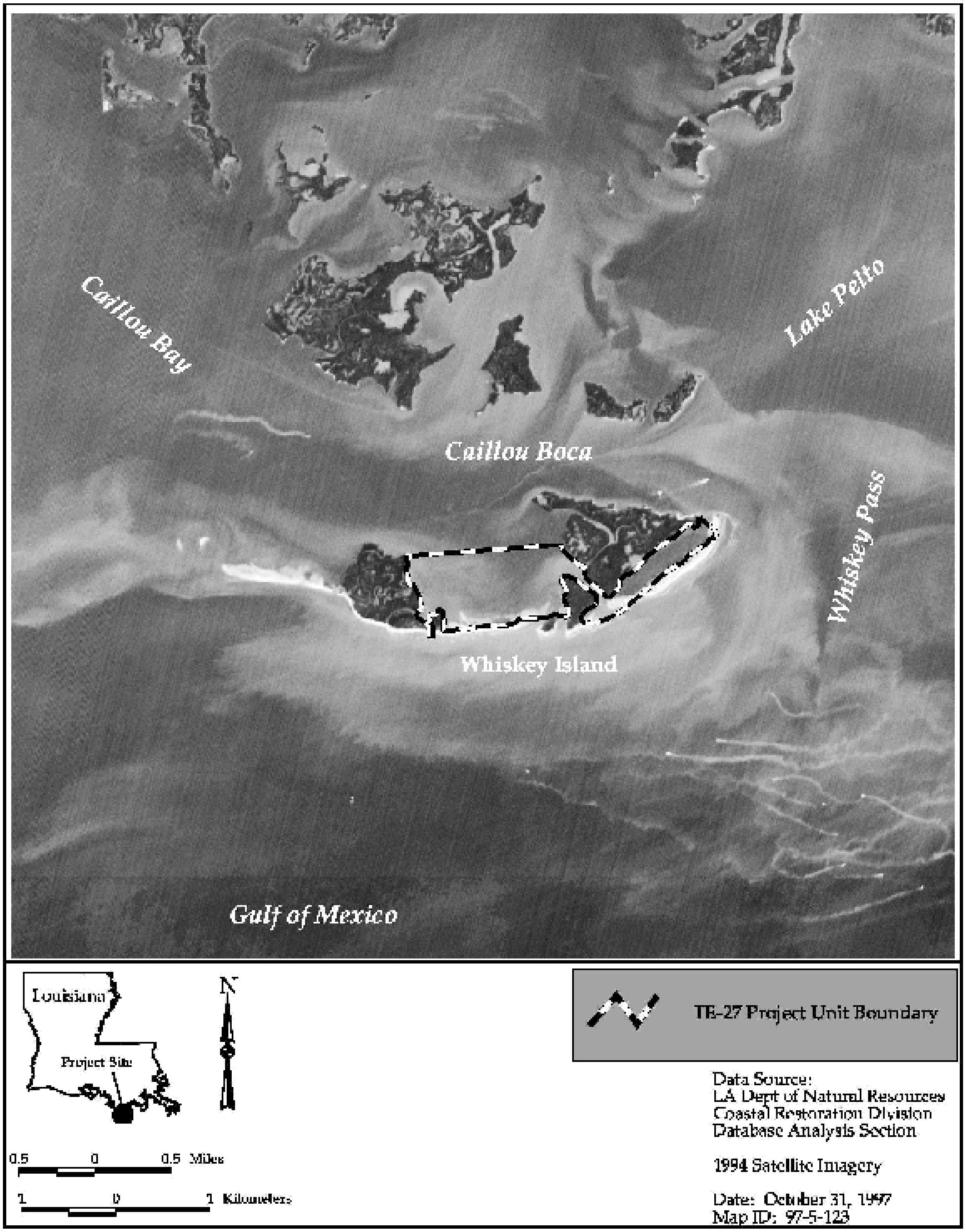

Figure 1: Whiskey Island, Terrebonne Parish, Louisiana, showing fill area.

project area are the sand beaches and the salt water marsh, clays and mucky clays (U.S. Soil Conservation Service 1960). Fine sand and shells distributed as the result of wave and wind action compose the sand beaches (Sc) soil type. The sediments may be from other beaches that have eroded or from the floor of the Gulf of Mexico. On Whiskey Island, extending inland of the sand beaches soil type is the salt water marsh, clays and mucky clays (Sa) soil type. This soil type consists of alluvial sediments which, through time, have been reworked by waves and tides. They occur at near-gulf level and are frequently flooded by normal tidal action. The sediments may be covered by several feet of salt water and transported inland during strong wind and/or storm events.

The beach vegetation is limited to *Ipomoea pes-caprae* (beach morning-glory) which colonizes the beach wrack line, and *Sesuvium portulacastrum* (seaside purslane) which survive minor washover events and accumulate sand to form characteristic low rounded dunes. Mangrove-saltmarsh, typical of the area and composed of *Spartina alterniflora* (smooth cordgrass), *Avicennia germinans* (black mangrove), *Batis maritima* (saltwort), and *Salicornia bigelovii* (bigelow glasswort) is found landward of the washover sheet. This mangrove-saltmarsh forms the dense organic mat that persists as the sand and shell dunes migrate over it. With further coastal erosion the mat is exposed as the characteristic "marsh platform" of the nearshore intertidal zone (Ritchie et al. 1989).

The Whiskey Island Restoration project included the creation of approximately 355 acres (177 ha) of supratidal (beach, dune, barrier flat) and intertidal (beach, marsh) habitat using sediments dredged from Whiskey Pass (figure 2). Target elevations ranged from +1 ft (0.3 m) to +4 ft (1.2 m) North American Vertical Datum of 1988 (NAVD 88). Vegetation was planted along the artificial fill surface to establish a protective cover that would facilitate fill stabilization as well as minimize wind-driven transport. Planted vegetation included *S. alterniflora* (smooth cordgrass), *Spartina patens* (marshhay cordgrass), *Panicum amarum* (bitter panicum), and *A. germinans* (black mangrove). Construction of the Whiskey Island Restoration project commenced in February 1998 and was completed in the Spring of 1999. The first phase of construction included hydraulic dredging of sediments from Whiskey Pass using a 30" Cutter Head Suction Dredge (7,200 hp) and Booster Pump Barge and was completed in late summer 1998. Approximately 2.9 million yd^3 (2.2 million m^3) of sediment were dredged from Whiskey Pass (borrow area) and placed on Whiskey Island (figure 2). Most of the dredged material was placed landward of the gulfside beach to restore the back-barrier portion of the island. Some material, however, was pumped onto the existing beach along the central portion of the island, in the vicinity of several breaches, as well as along the eastern section of the island near Coupe Nouvelle (figure 2).

The second phase of construction was conducted in the Spring of 1999 and included the planting of several native species of vegetation along the newly restored dune terrace and back-barrier beach. In total, 14,200 *S. alterniflora*, 9,333 *S. patens*, 9,333 *P. amarum*, and 1,625 *A. germinans* were planted. The first vegetation sampling was conducted August 24 and 25, 1999 and additional vegetation sampling occurred September 19-20, 2001 and September 15, 2003.

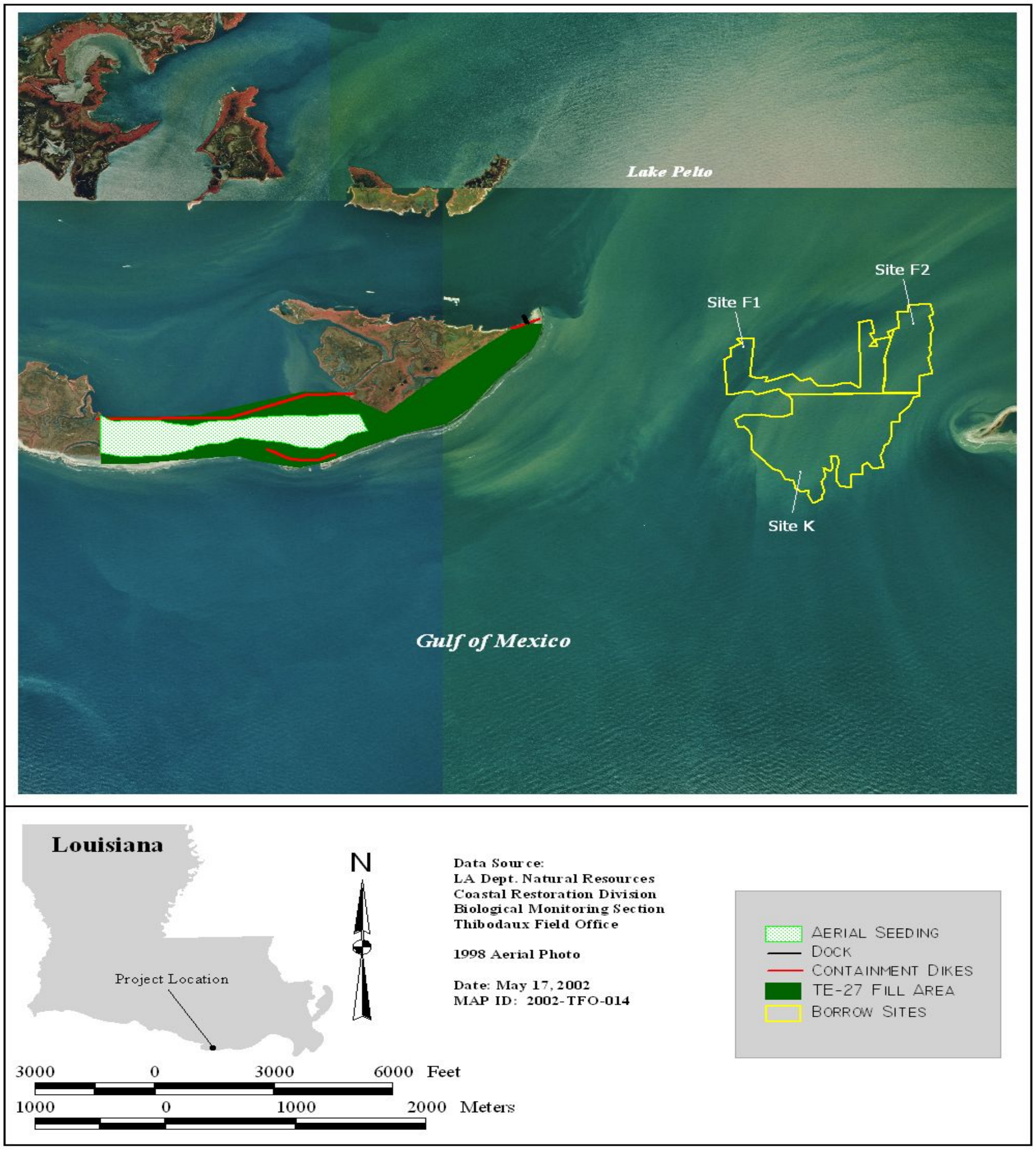

Figure 2: Project construction area, associated structures, and borrow sites for Whiskey Island Restoration (TE-27).

II. Maintenance Activity

This project has no operations and maintenance budget and no maintenance has been done.

III. Operation Activity

This project has no operations and maintenance budget and no operations are required.

IV. Monitoring Activity

a. Monitoring Goals

The objectives for the this project are to strengthen and stabilize Whiskey Island through sediment addition and vegetative growth which will maintain the protective barrier between the Gulf of Mexico and the lower Terrebonne Basin estuary system.

The following goals will contribute to the evaluation of the above objective:

1. Increase the elevation and width of Whiskey Island using dredged sediments.

2. Reduce loss of dredged sediments through the growth of vegetation

b. Monitoring Elements

The following monitoring elements will provide the information necessary to evaluate the specific goals listed above:

Aerial Photography

The 1997, near vertical color-infrared 1:12,000 scale aerial photography, obtained by the United States Geological Survey/National Wetlands Research Center (USGS/NRWC) was checked for flight accuracy, color correctness, and clarity. The original film was archived and duplicate photography was indexed and scanned at 300 dots per inch. Using ERDAS Imagine®, an image processing and geographic information systems (GIS) software package, individual frames of photography were geo-rectified using a real-time differentially corrected global positioning system (DGPS) data with sub-meter accuracy. These rectified frames were then assembled to produce a mosaic for the island. This mosaic provides a pre-construction picture of the island. Due to budgetary constraints and project goals and objectives, photography and analysis was removed from the project monitoring.

During April and November 2002, Coastal Research Laboratory, University of New Orleans (UNO) acquired color-infrared (CIR) aerial photographs of the project area [and also for East Island (TE-20), Trinity Island (TE-24), East Timbalier Phase 1 (TE-25), and East Timbalier Phase 2] for the purpose of Adaptive Management Review of constructed projects and post hurricane Lillie assessments. Habitat analysis was conducted and change comparisons were provided by UNO to 1996 photography.

Elevation

To document both horizontal and vertical change along the constructed area of Whiskey Island, transect lines were established at 200 ft (60.9 m) intervals by professional surveyors before construction. Elevation was determined every 100 ft (30.5 m) across the island along each transect. Post-construction (as-built) surveys were conducted in December 1998 to correspond with vegetation sampling and to avoid disturbance of nesting birds on the island. Beginning in 2000, airborne light detection and ranging (LiDAR) surveys replaced conventional on-the-ground surveys. Airborne LiDAR surveys collect data along lines the entire length of the island versus the traditional transects used in conventional surveys. LiDAR surveys were conducted in October 2000 by Morris P. Hebert, and again in 2001 and 2002 by USGS. LiDAR surveys will be repeated in 2007 and 2016. Data collected was used to develop elevational triangulation-based (TIN) surface generation models and subsequent Grid models in ArcView®. Difference grids were created by subtracting earlier grids from succeeding grids. Volume change for these difference grids as well as volume for each of the 2000, 2001, and 2002 LiDAR grids were calculated with the cut/fill calculator in the LiDAR data handler extension of ArcView®. All grids were clipped to the same area as volume calculations that include areas with no data cannot be performed. The 2000 LiDAR survey has ± 10 cm accuracy while surveys performed in 2001 and 2002 have ± 15 cm accuracy (Sallenger et al. 2003). LiDAR grids were not filtered for vegetation.

Vegetation

Species composition and percent cover of vegetation in four treatments, dune, spur, bay, and unplanted areas (figure 3), were determined using the Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974) as described in Steyer et al. (1995). Species in 4 m^2 plots were recorded, and visual estimates of percent cover for the total plot and individual species were made. Cover classes used were: solitary, <1%, 1-5%, 6-25%, 26-50%, 51-75%, and 76-100%. Vegetation outside of each plot but within 33 ft (10 m) were also identified and recorded. Vegetation plots were chosen randomly in the planted areas (dune, spur, and bay). Each plot was established using a vegetation station marker stake as its southeast corner and plots were oriented in a North-South direction. Unplanted treatment plots were established between the spurs, using randomly chosen distances from the spur plots. Twelve plots were established in August 1999 for each of the treatments. Planted vegetation consisted of *P. amarum* and/or *S. patens* in the dune plots, *P. amarum* in the spur plots, and *S. alterniflora* in the bay plots. Differential Global Positioning System (DGPS) coordinates were also collected at each stake to facilitate re-establishment of stations in the future. Vegetation sampling for each of the dune, bay, spur, and unplanted 4 m^2 plots continued in September 2001 and 2003. Field personnel made visual estimates of percent cover for the total plot and each individual species. If a plot was unable to be located (i.e., the marker stake was gone), a new plot was established. However, a new plot was not established if the original plot was now underwater or had eroded. In these cases, percent cover was recorded as 100% open water for data analysis.

Importance values were calculated by adding the relative percent cover to the relative frequency for each species (Courtemanche et al. 1999). Mean importance values were determined by separating species into categories of planted, seeded, appearance via natural vegetative recruitment or re-colonization, and bare ground. Importance values provide a useful and more realistic measure of dominance. Plots located in open water were not used in importance value calculations.

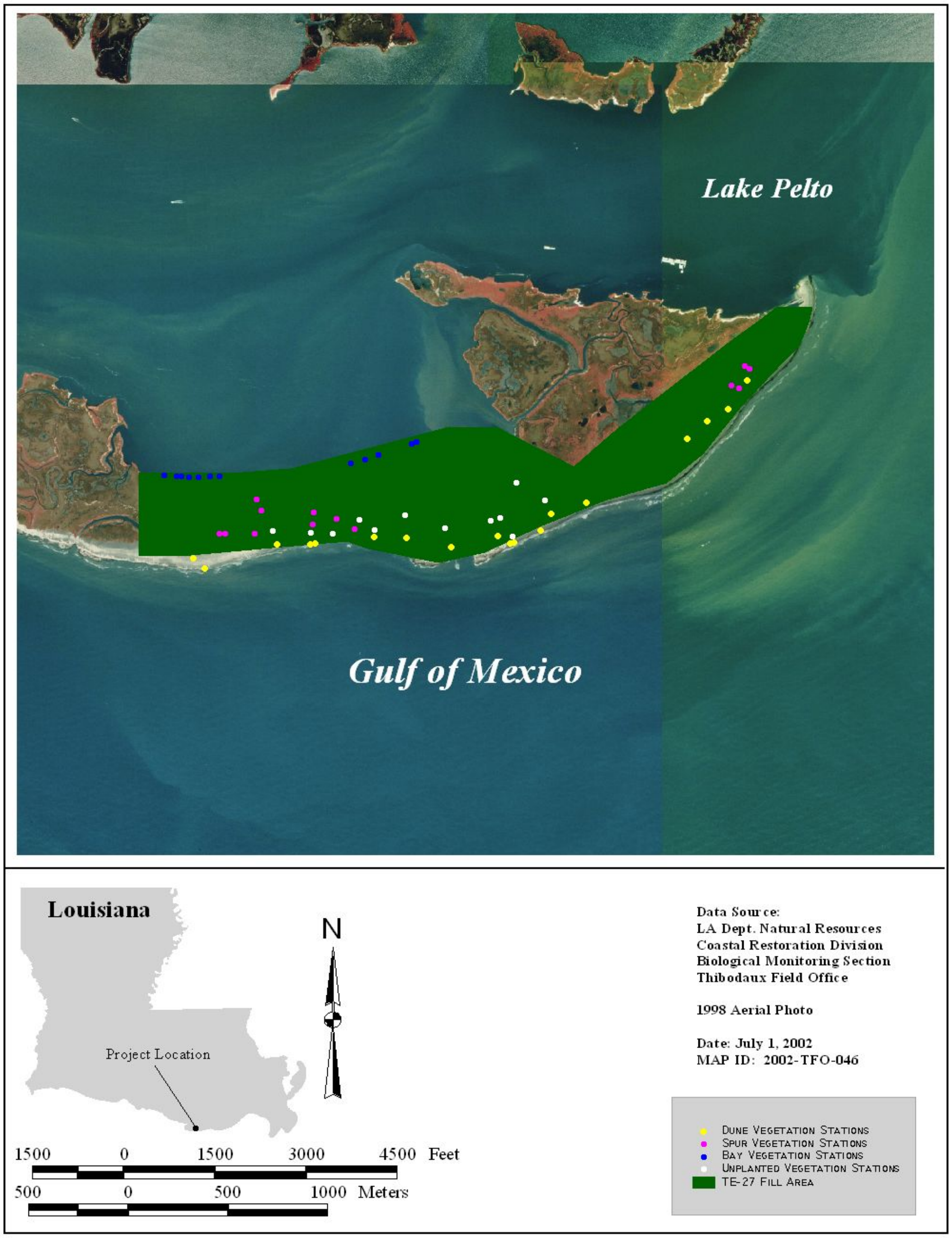

Figure 3: Location of each of the vegetation sampling plots on Whiskey Island.

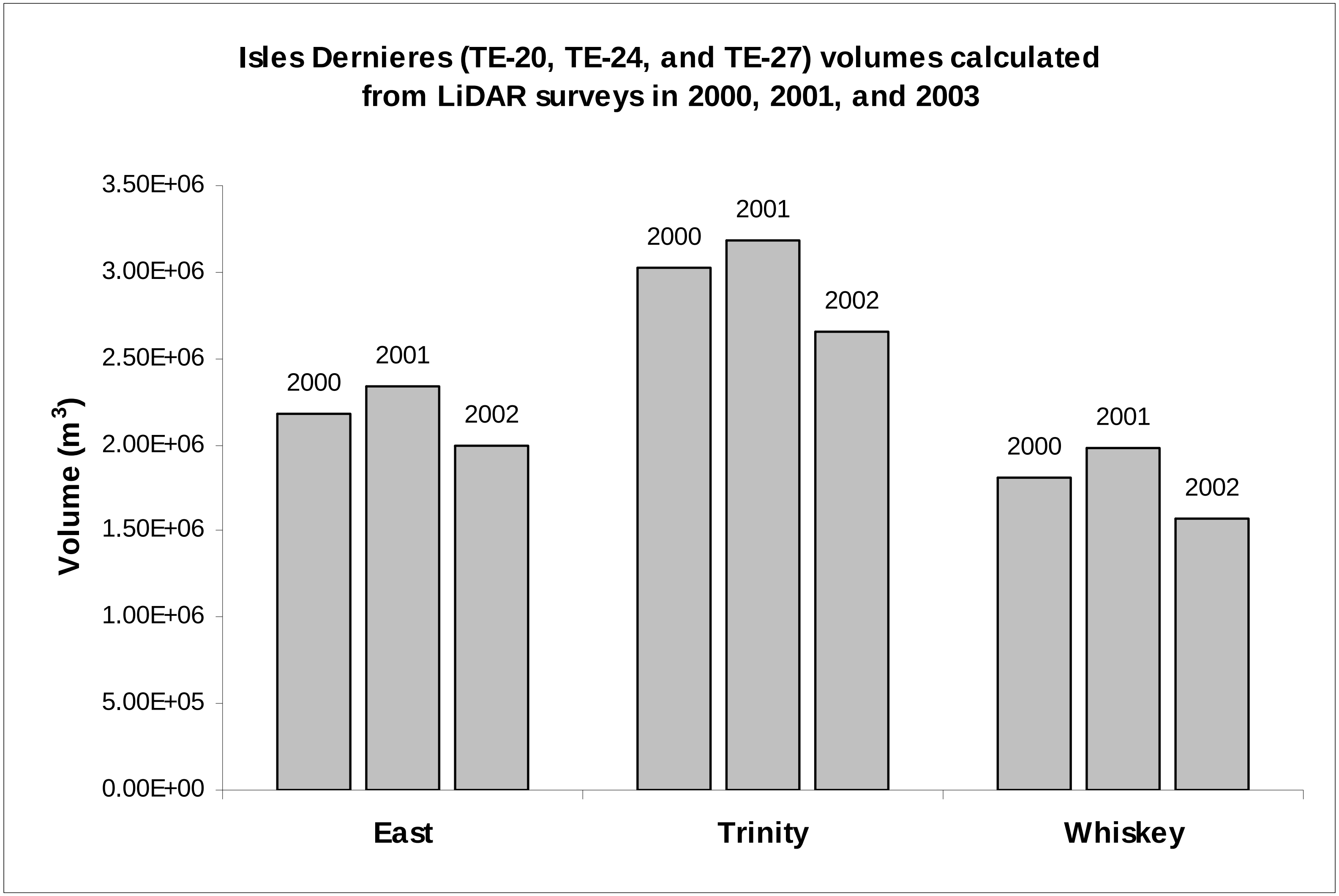

Figure 4: Volumes of East, Trinity, and Whiskey Isles Dernieres calculated from grids created from LiDAR surveys in ArcView®.

c. Preliminary Monitoring Results and Discussion

Aerial Photography

Analysis done by UNO indicated that the project contributed to a 168.03 acre increase in the overall size of the island from pre- to post-construction (1996 to May 2002) (table 1). Penland et. al. (2003) stated that this project's gains accounted for a predicted 13 year increase in island longevity. However, after Tropical Storm Isidore and Hurricane Lili in 2002, post-storm photography showed 50.40 acres of land loss, or approximately one-third of the initial gains, to a total land mass of 529.42 acres.

Elevation

Currently, we are still in the process of converting pre-construction and as-built survey data collected via conventional survey methods to Louisiana Department of Natural Resources-South Louisiana Coastal Wetland GPS network datum. LiDAR surveys conducted in 2000, 2001, and 2002 displayed that initially Whiskey Island along with the other Isles Dernieres may have been gaining volume prior to Tropical Storm Isidore (September 2002) and Hurricane Lili (October 2002) striking the island (figure 4). Calculated changes for Whiskey Island include a 9% increase in volume between 2000 and 2001 and a 20% decrease between 2001 and 2002 surveys. These percentage changes in volume are consistent with other Isles Dernieres (figure 4; West 2004a, b).

Vegetation

Initial monitoring indicated that vegetation survival one growing season after planting was very low possibly due to drought after planting (<30%; Townson et al. *Unpublished*; Khalil and Lee *in press*). Additionally, vegetative cover in planted areas was low (<15%), indicating alternate planting designs need to be considered in future projects to maximize cover of bare sediment faster (Townson et al. *Unpublished*). The three planted species, *S. alterniflora*, *S. patens*, and *P. amarum*, dominated vegetative cover in 1999 and 2001 sampling trips with *S. patens* showing good lateral spread. Elevation models from surveys indicate volume loss of sediment 1.5 years after deposition >21,600 cubic yards of sediment from wind and overwash events indicating the need for sand fencing soon after construction (Townson et al. *Unpublished*; Khalil and Lee *in press*).

In 2003, 18 of the 20 dune plots (the other 2 were in the surf zone and 100% bare ground), 6 of the 12 bay plots, 2 of the 12 unplanted plots, and 4 of the 12 spur plots were underwater (figure 5). These results suggest that Whiskey Island continues to narrow, to rollover, and to experience considerable erosion. Percent cover of bare ground tended to decrease with each subsequent year. However, these results may be due to the number of plots that have change to open water as vegetative cover also decreased between 2001 and 2003. Percent cover of vegetation for dune, bay, spur, and unplanted plots in 2003 was 0.0%, 50.0%, 18.1%, and 8.2%, respectively. Dune, spur, and unplanted plots had a considerable decrease in percent cover of vegetation between 2001 and 2003.

Dune plots had high species diversity in 1999 but had 0% vegetative cover in 2003. Percent cover of *S. alterniflora* remained fairly constant between 2001 and 2003 in bay plots (table 2) even considering the loss of suitable habitat to open water. In the spur plots, the percent cover of *S. patens* and *P. amarum* decreased slightly between 2001 and 2003 (31.1% total cover to 17.9%). There was a sizable decrease in native vegetation in the spur plots (from 6.8% in 2001 to 0.2% in 2003) as the only other species recorded in these plots were *S. portulacastrum* and *S. bigelovi* (only 1% cover in one plot). In the unplanted plots, native vegetative remained fairly constant among all sampling years but the appearance of *S. patens* and *P. amarum* in 2001 and 2003 suggests that the planted species are dispersing into unplanted areas. The slow decrease in *S. portulacastrum* cover in all plots among all years may be indicative of the loss changing suitable habitat due barrier island erosion. No considerable changes were evident in native vegetation cover in the unplanted plots (6.7% in 1999 to 8.2% in 2001 to 5.5% in 2003). No *A. germinans* were in any 4 m^2 plot, but several of these plants were seen on the island near various plots.

Vegetation sampling within the 4 m^2 plot consistently underestimated species richness as compared to the surrounding 10 ft (33 m) of the plot (figure 6). This result may indicate an insufficient number of plots established to accurately characterize the vegetative communities on the island. Species richness and importance values for vegetation decreased between 2001 and 2003 (figure 7). Bare ground showed a marked increase between 2001 and 2003. Whiskey Island was not aerially seeded and no sand fences were constructed. In the other Isles Dernieres where aerial seeding was conducted and sand fences were used had a decrease in bare ground importance and an increase in species diversity between 2001 and 2003 (West 2004a, b). The use of sand fencing and aerial seeding may be important for barrier island vegetative succession. However, the high loss of vegetative plantings due to the aforementioned drought may also be an important factor.

Table 1: Habitat classification acreages for 1996 and 2002 Photography by UNO.

Classification	12-9-1996 (acres)	5-14-2002 (acres)	11-7-2002 (acres)
beach	165.01	102.15	63.82
bare	2.47	196.47	187.84
marsh	304.08	296.74	270.08
barrier vegetation	3.23	47.46	7.68
structure	0.98	1.06	0.94
rip rap	0.00	0.00	0.00
intertidal	73.48	52.94	321.04
total land only	***474.79***	***642.82***	***529.42***

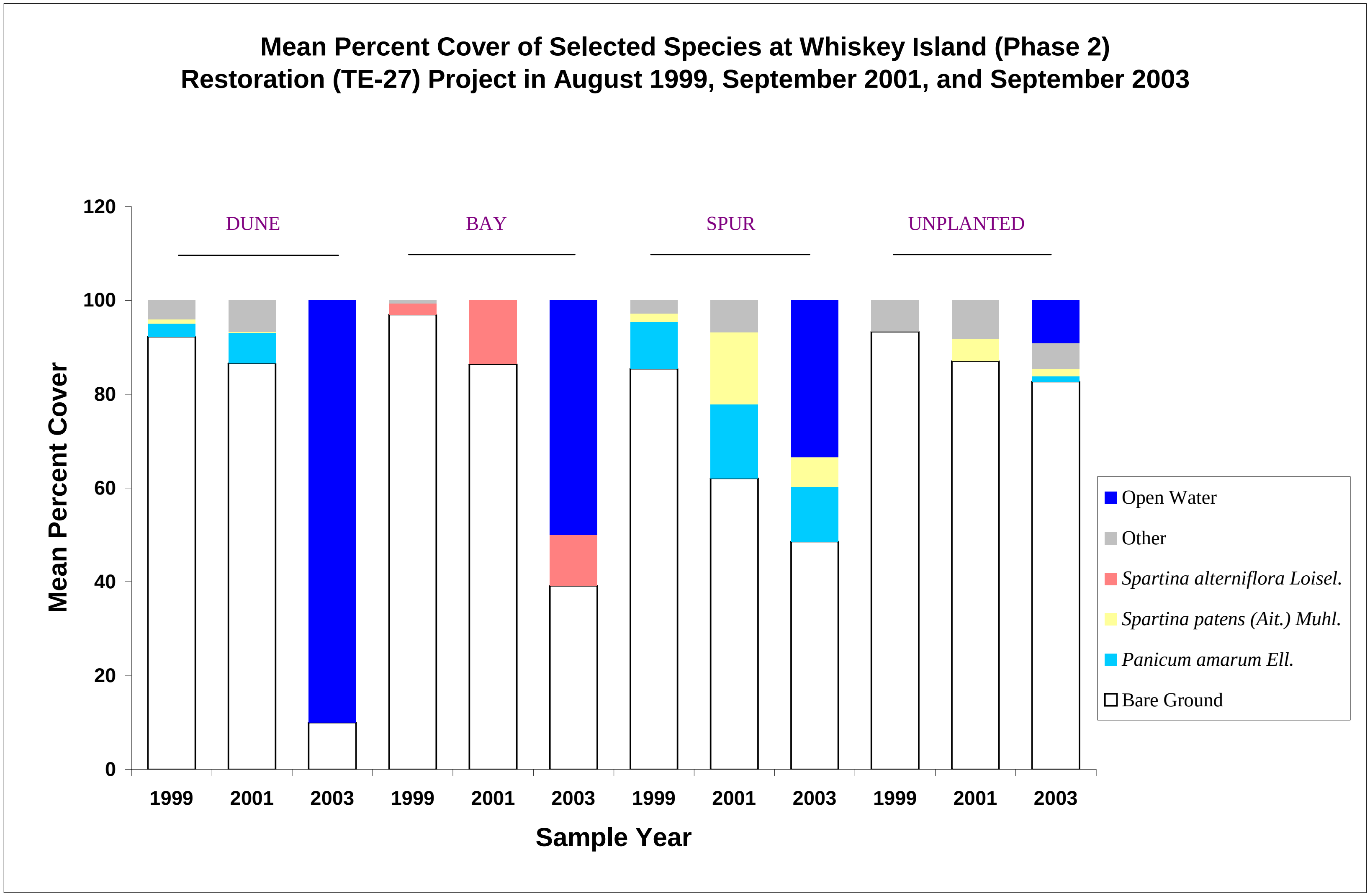

Figure 5. Mean percent cover for selected vegetation species at Whiskey Island Restoration (TE-27).

Table 2: Estimated mean percent cover for all species occurring during the 1999, 2001, and 2003 sampling of the 2x2 m Braun-Blaunqet vegetation plots at Whiskey Island.

	Dune					
	1999		2001		2003	
	% Stations	**Mean Cover**	**% Stations**	**Mean Cover**	**% Stations**	**Mean Cover**
Bare Ground	100.00	93.10	100.00	88.20	10.00	100.00
Batis maritima L.						
Cakile constricta Rodman	5.00	5.00				
Croton punctatus Jacq.	10.00	10.05	10.00	4.50		
Distichlis spicata (L.) Greene	5.00	5.00				
Fimbristylis Vahl						
Heliotropium curassavicum L.						
Ipomoea imperati (Vahl) Griseb.	45.00	4.44	40.00	14.69		
Ipomoea pes-caprae (L.) R. Br.	5.00	5.00	10.00	0.75		
Panicum amarum Ell.	20.00	14.00	30.00	21.87		
Phytolacca americana L.	5.00	3.00				
Salicornia bigelovii Torr.						
Sesuvium portulacastrum (L.) L.	25.00	0.62				
Spartina alterniflora Loisel.						
Spartina patens (Ait.) Muhl.	30.00	3.02	15.00	1.33		
Strophostyles helvula (L.) Ell.			5.00	10.00		
Suaeda linearis (Ell.) Moq.						
Vigna luteola (Jacq.) Benth.	5.00	0.50				
Open Water					90.00	100.00

Table 2 cont.

	Bay					
	1999		2001		2003	
	% Stations	Mean Cover	% Stations	Mean Cover	% Stations	Mean Cover
Bare Ground	100.00	97.00	100.00	93.33	50.00	78.33
Batis maritima L.						
Cakile constricta Rodman						
Croton punctatus Jacq.						
Distichlis spicata (L.) Greene						
Fimbristylis Vahl						
Heliotropium curassavicum L.						
Ipomoea imperati (Vahl) Griseb.						
Ipomoea pes-caprae (L.) R. Br.						
Panicum amarum Ell.						
Phytolacca americana L.						
Salicornia bigelovii Torr.						
Sesuvium portulacastrum (L.) L.	33.33	2.00				
Spartina alterniflora Loisel.	66.67	3.50	58.33	25.21	33.33	32.50
Spartina patens (Ait.) Muhl.						
Strophostyles helvula (L.) Ell.						
Suaeda linearis (Ell.) Moq.						
Vigna luteola (Jacq.) Benth.						
Open Water					50.00	100.00

Table 2 cont.

	Spur					
	1999		2001		2003	
	% Stations	Mean Cover	% Stations	Mean Cover	% Stations	Mean Cover
Bare Ground	91.67	85.55	100.00	67.00	66.67	72.88
Batis maritima L.						
Cakile constricta Rodman						
Croton punctatus Jacq.						
Distichlis spicata (L.) Greene						
Fimbristylis Vahl						
Heliotropium curassavicum L.	8.33	4.00	10.00	0.50		
Ipomoea imperati (Vahl) Griseb.			20.00	0.30		
Ipomoea pes-caprae (L.) R. Br.						
Panicum amarum Ell.	25.00	36.67	20.00	85.00	25.00	46.70
Phytolacca americana L.						
Salicornia bigelovii Torr.			30.00	0.50	8.33	1.00
Sesuvium portulacastrum (L.) L.	50.00	4.33	20.00	35.25	8.33	1.00
Spartina alterniflora Loisel.						
Spartina patens (Ait.) Muhl.	8.33	20.00	40.00	41.38	25.00	25.00
Strophostyles helvula (L.) Ell.						
Suaeda linearis (Ell.) Moq.			10.00	0.50		
Vigna luteola (Jacq.) Benth.						
Open Water					33.33	100.00

Table 2 cont.

	Unplanted					
	1999		2001		2003	
	% Stations	**Mean Cover**	**% Stations**	**Mean Cover**	**% Stations**	**Mean Cover**
Bare Ground	100.00	93.50	100.00	84.58	90.91	91.00
Batis maritima L.	8.33	0.50				
Cakile constricta Rodman						
Croton punctatus Jacq.						
Distichlis spicata (L.) Greene	8.33	1.00	8.33	0.50		
Fimbristylis Vahl	8.33	0.50				
Heliotropium curassavicum L.						
Ipomoea imperati (Vahl) Griseb.			8.33	0.50		
Ipomoea pes-caprae (L.) R. Br.						
Panicum amarum Ell.					18.18	6.55
Phytolacca americana L.						
Salicornia bigelovii Torr.	8.33	6.00	33.33	0.78		
Sesuvium portulacastrum (L.) L.	33.33	18.00	41.67	18.40	27.27	20.03
Spartina alterniflora Loisel.					9.09	0.10
Spartina patens (Ait.) Muhl.			16.67	27.50	27.27	5.67
Strophostyles helvula (L.) Ell.						
Suaeda linearis (Ell.) Moq.			8.33	0.10		
Vigna luteola (Jacq.) Benth.						
Open Water					9.09	100.00

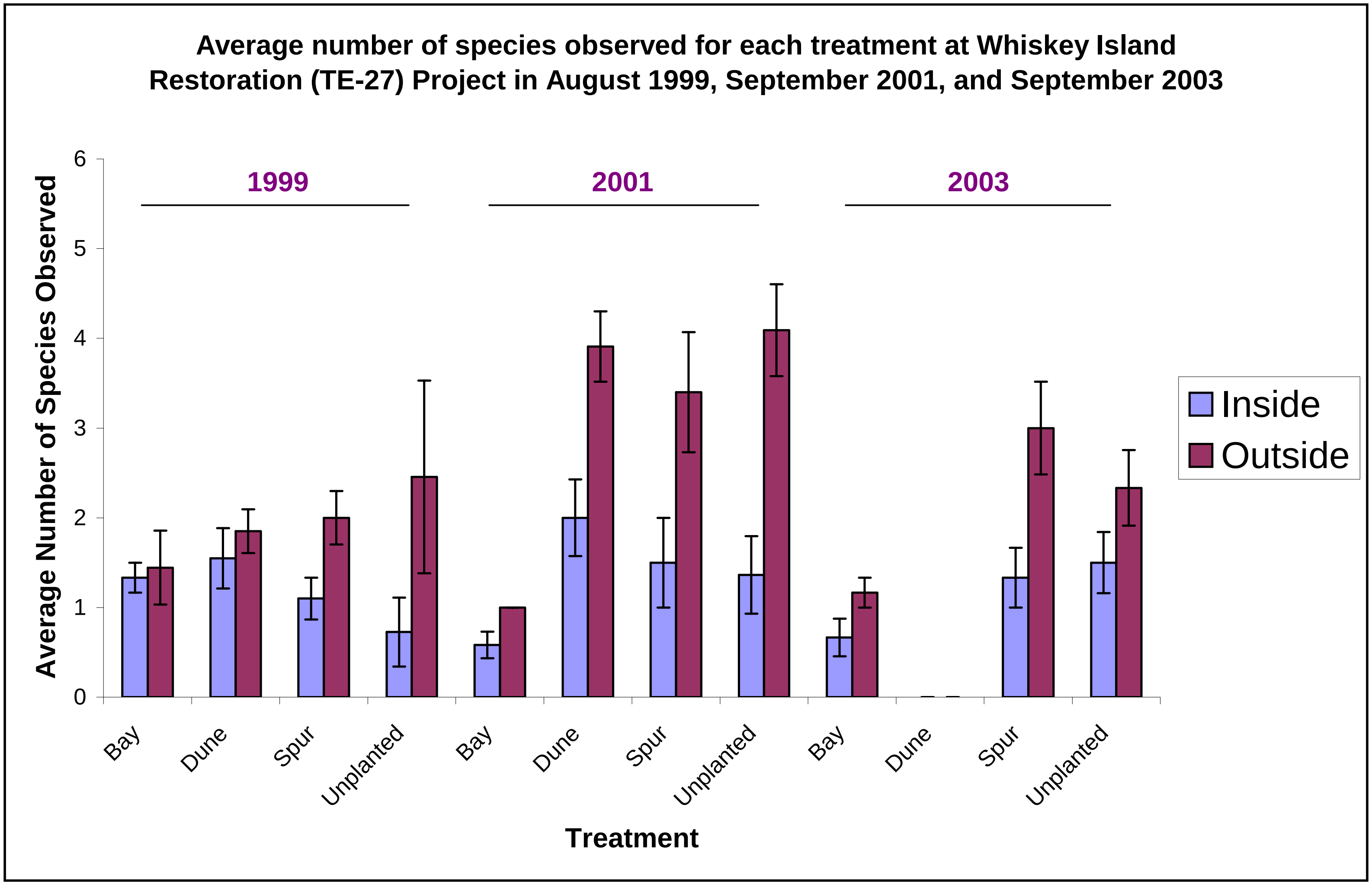

Figure 6. Average number of different vegetation species recorded inside and outside of each 4 m^2 plot at Whiskey Island Restoration (TE-27). Error bars represent one standard deviation from the mean.

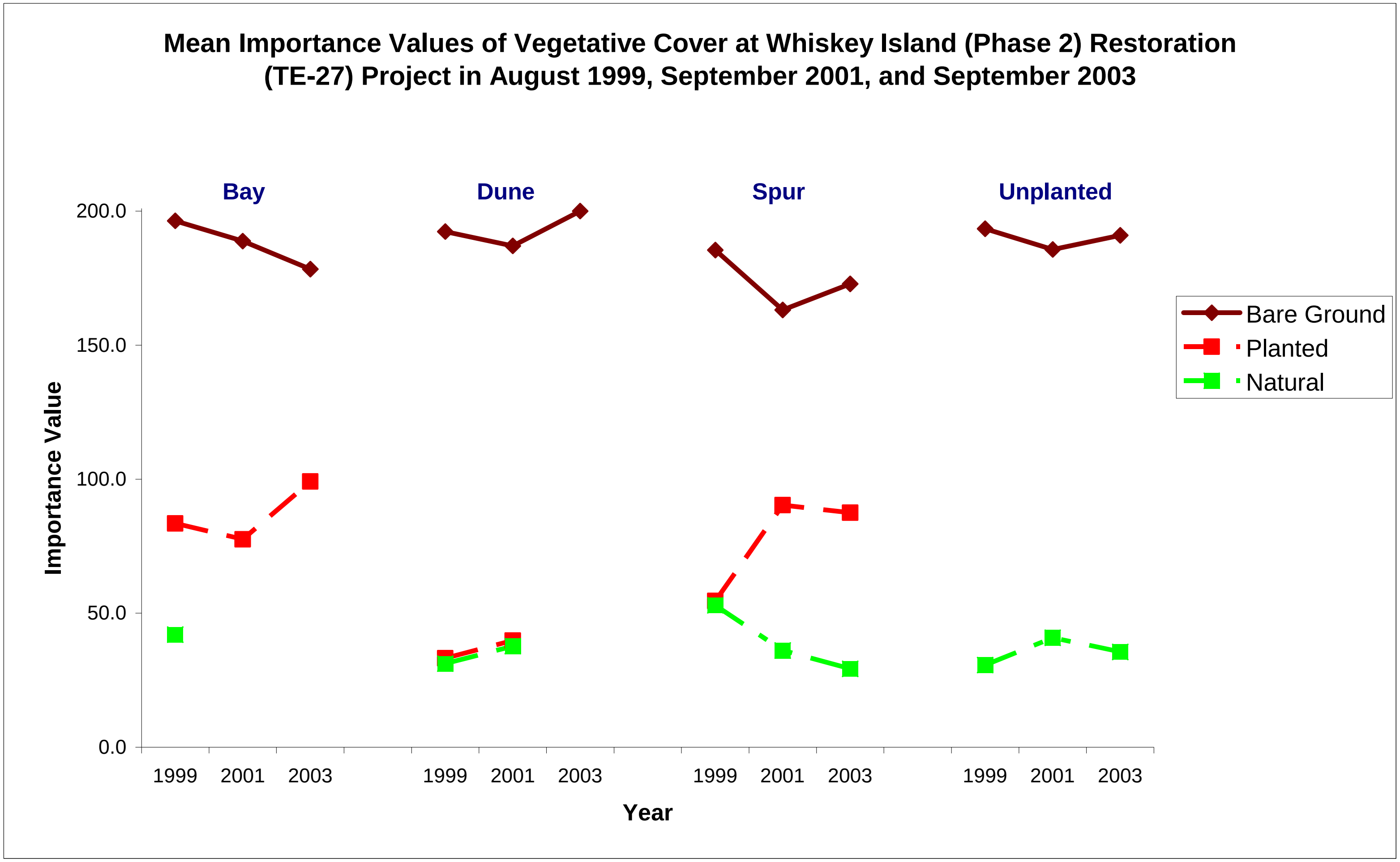

Figure 7: Mean importance values of different vegetation categories calculated at Whiskey Island (TE-27). The term natural represents species that were not planted and assumed colonized via natural means.

V. Conclusions

a. Project Effectiveness

Preliminary observations alleged that this project was effective at reducing barrier island erosion. However, subsequent sampling trips, especially those after Hurricane Lili, exhibited considerable loss of land on both sides of the island to open water and this loss is probably due to barrier island rollover and island narrowing. The survival of the bay and dune plots, in particular, is a factor of how the island shape is altered by wind and wave action. LiDAR results after Isidore and Lili further help to support these findings as well as provide evidence of elevational/volume decreases.

An increase in the number of species in vegetation plots does suggest that planting along the spurs helped to anchor fill material and sand in place as well as to allow native vegetation to disperse into newly created habitat. The increase in vegetative cover each year (except in dune plots) may also be indicative of some success at project effectiveness. However, landward migration may continue and future sampling trips may yield more losses of vegetation stations to open water.

This project initially succeeded its goal of increasing the height and volume of the island prior to the compounding effects of Isidore and Lili. Although some sediment was lost, this island did not become subaqueous due to proactive sediment fill and maintained some protection for mainland areas from these storms. Species diversity decreased between 2001 and 2003 for all treatments probably due to the lack of sand fencing, no aerial seeding of *C. dactylon*, or the loss of suitable habitat from the poor success of the planted species.

b. Recommended Improvements

Funding for maintenance of barrier island restoration projects was not considered due to the expense involved with replenishment of dredge material over the life expectancy of the project. In forgoing the funding of a barrier island maintenance program to replenish sediment lost to normal storm events, claims for FEMA assistance resulting from extensive or catastrophic storm damage to barrier islands from unexpected storms events such as tropical storms and hurricanes are considered ineligible. Based on monitoring activity of these islands, it has been documented that these barrier island are experiencing significant land loss due to barrier island rollover and island narrowing resulting from such unexpected storm events. Therefore, it is recommended that maintenance funds be provided for the implementation of an inspection and maintenance program for assessment and replacement of dredged sediment and sand fencing necessary to maintain the integrity of these islands. The implementation of a maintenance program for barrier island projects would enable these projects to qualify for assistance under the Federal Emergency Management Program.

c. Lessons Learned

Initial lessons learned include adjusting the establishment of planting survival plots to better analyze the yearly success of planted vegetation (cf. Townson et al. *Unpublished*). This adjustment can include resizing plots or increasing the number of the plots established. Increasing the number of the established plots may also help accurately characterize the vegetative communities on the island.

The use of dredged sediment, sand fencing, and vegetative plantings are plausible ways to create quasi-stabilization and further prolong the lives of barrier islands. These three techniques should be used in conjunction and the construction of sand fencing as well as vegetative planting should occur as soon as possible after the placement of dredged sediment to minimize soil loss. Furthermore, a different vegetative planting design must be determined to allow vegetative colonization in a sufficient time frame as to maximize sediment stabilization.

Barrier islands are often exposed to storm events resulting in substantial over-wash and breaching. To combat these processes, it is important that a continuous dune of sufficient height and width is maintained on these islands. Other than periodically replenishing sediment by hydraulic dredge, sand fencing has proven to be an effective technique in rebuilding dunes by capturing wind blown sediment. We have learned from past projects that orienting the sand fencing parallel to the shore face and perpendicular to the predominant wind direction has maximized the potential for maintaining a viable dune section.

References

Courtemanche, R.P., M.W. Hester, and I.A. Mendelssohn. 1999. Recovery of a Louisiana barrier island marsh plant community following extensive hurricane-induced overwash. Journal of Coastal Research 15:872-883.

Frazier, D.E. 1967. Recent deposits of the Mississippi River, their development and chronology. Transactions, Gulf Coast Association of Geological Societies 17: 287-311.

Khalil, S.M. and D.M. Lee. *In Press*. Restoration of Isles Dernieres, Louisiana: some reflections on morphodynamic approaches in the northern Gulf of Mexico to conserve coastal/marine systems. Journal of Coastal Research.

List, J.H., B.E. Jaffe, A.H. Sallenger, and M.E. Hansen. 1997. Bathymetric comparisons adjacent to the Louisiana barrier islands: processes of large scale change. Journal of Coastal Research 13:670-678.

McBride, R.A., and M.R. Byrnes 1997. Regional variations in shore response along barrier island systems of the Mississippi River Delta Plain: historical change and future prediction. Journal of Coastal Research 13: 628-655.

McBride, R.A., M. W. Hiland, S. Penland, S.J. Williams, M.R. Byrnes, K.A. Westphal, B.E. Jaffee, and A.H. Sallenger, Jr. 1991. Mapping barrier island changes in Louisiana: techniques, accuracy, and results. Seattle, WA: Coastal Sediments '91 Proceedings. pp 1011-1025.

McBride, R.A., S. Penland, B.E. Jaffe, S.J. Williams, A.H. Sallenger, and K.A. Westphal. 1989. Erosion and deterioration of the Isles Dernieres barrier island arc-Louisiana, U.S.A.: 1853-1988: Transactions of the Gulf Coast Association of Geological Societies 39:431-444.

Mueller-Dombois, D. and H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology*. John Wiley and Sons, New York. 547 pp.

Penland, S., and R. Boyd. 1985. Transgressive depositional environments of the Mississippi River delta plain: A guide to the barrier islands, beaches and shoals of Louisiana: Louisiana Geological Survey Guidebook Series No. 3, 233 pp.

Penland, S., P. Conner, F. Cretini, and K. Westphal. 2003. CWPPRA adaptive management: Assessment of five barrier island restoration projects in Louisiana. Prepared for LA Dept. Natural Resources, Office of Coastal Restoration and Management, Baton Rouge, LA by the Pontchartrain Institute for Environmental Sciences, Univ. of New Orleans. New Orleans, LA. 64 pp + appendices

Penland, S. and Ramsey, K.E. 1990. Relative sea-level rise in Louisiana and the Gulf of Mexico: 1908-1988. Journal of Coastal Research 6:323-342.

Penland, S., J.R. Suter, and R. Boyd. 1988. The transgressive depositional systems of the Mississippi River delta plain: A model for barrier shoreline and shelf sand development. Journal of Sedimentary Petrology 58:932-949.

Ritchie, W., K. Westphal, R. A. McBride, and S. Penland. 1989. Coastal Sand Dunes of Louisiana: The Isles Dernieres. Baton Rouge, LA and Aberdeen, Scotland: Coastal Geology Technical Report No. 5.

Sallenger, A.H., W.B. Krabill, R.N. Swift, J. Brock, J. List, M. Hansen, R.A. Holman, S. Manizade, J. Sontag, A. Meredith, K. Morgan, J.K. Yunkel, E.B. Frederick, and H. Stockdon. 2003. Evaluation of airborne topographic LiDAR for quantifying beach changes. Journal of Coastal Research. 19:125-133.

Steyer, G.D., R.C. Raynie, D.L. Steller, D. Fuller and E. Swenson. 1995. Quality management plan for Coastal Wetlands Planning, Protection, and Restoration Act monitoring program. Open-file series no. 95-01. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division.

Townson, M.A., C.K. Armbuster, and N. Clark. *Unpublished*. Isles Dernieres Restoration Project Phase 1 (TE-24) Progress Report.

United State Department of Agriculture, Soil Conservation Service. 1960. Soil Survey of Terrebonne Parish, Louisiana. Series 1956, No. 1.

West, J.L. and D. Dearmond. 2004a. 2004 Operations, Maintenance, and Monitoring Report for Isles Dernieres Restoration East Island (TE-20), *Louisiana Department of Natural Resources, Coastal Restoration Division, Thibodaux, Louisiana.* 21pp.

West, J.L. and D. Dearmond. 2004b. 2004 Operations, Maintenance, and Monitoring Report for Isles Dernieres Restoration Trinity Island, *Louisiana Department of Natural Resources, Coastal Restoration Division, Thibodaux, Louisiana.* 21pp.